INTRODUCTION

ENGINEERING AND TECHNOCRATIC VISIONS IN MEXICO

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This book is about experts, technology, and networks in Mexico. It focuses on the period between the mid-nineteenth century and mid-twentieth century, an era some historians align with the Second Industrial Revolution and Mexico's transition to a more industrialized, fossil fuel–geared economy.[1] Some of this volume's authors, however, delve as far back as the pre-Colombian era and other authors bring their analysis up to the twenty-first century. Most the contributors focus on engineers, especially civil engineers, but also on mining engineers, military engineers, architects, and various other infrastructural and mechanical technicians. Bringing together Mexican and US historians with a range of overlapping interests and fields of study, this volume provides a diverse representation of histories about expertise, technocracy, and technology in Mexico.

We examine these engineers and other experts because we think their lives provide important and unique ways of studying how technology and people intersect to create societal and environmental change.[2] Mexican engineers, like their counterparts in other parts of the world, have served as brokers. They mediate between local communities, multiple levels of governance, and multinational and domestic corporations.[3] Their lives reveal a Mexico with competing and intertwining technological vernaculars and lived experiences. We argue that understanding more about the context and use of technological networks, that is, the people who first constructed them, maintained them, and resisted them, is important to creating more

informed conversations today about why, how, and by whom these networks are built and to whose benefit.

ENGINEERS AND TECHNOCRATS

So, who gets to count as an engineer? After all, anybody who designs or builds something technically engineers it. In that sense people have been engineering things since they learned to light fires, turn plants and animals into pigments for cave paintings, and knap rocks into tools. The term "engineer" was not even commonly used in Western societies outside of people who worked on war equipment until the eighteenth century.[4] Before then construction works and mechanical creations were carried out largely by local craftspeople or city guild members. The people of the Americas, especially those in more technologically complex civilizations, such as the Inca and Aztec, possessed a variety of specialists. The society in and around Tenochtitlán, the Aztec capital centered in the middle of Lake Texcoco, possessed people who designed and built temples, roads, aqueducts, canals, dikes, docks, and *chinampas*.[5] Colonial practices and subsequent Mexican methods competed and merged with a myriad of previously established practices. The engineers who are the subject of this book were often professionally trained in formal, Western-style architecture and engineering programs in the late 1800s and early 1900s in Mexico, Europe, or the United States. They were part of the broader globalization of the profession. But these professionals interacted with other people who engineered their environments with or without engineers.

The rise of professional engineering programs brought significant changes to Mexico as it did elsewhere. They facilitated intellectual exchanges with other nations even while in Mexico they also networked people interested in strengthening Mexican sovereignty. Confirmed by state, business, and military elites, engineers became determining agents in matters of infrastructural development and certain extraction enterprises and industrial projects, at least in the eyes of those elites and engineers. In the process the elevation of professional engineers attacked the legitimacy of local knowledge and technicians who did not conform to modern methods of standardization, building practices, and concepts of hygiene, safety, and order.

The participation of engineers and other technical experts in government circles in the late 1800s coincided with the rise of technocrats in the Mexican state. As such, *Technocratic Visions* is also about technocracy. Many people who study Mexico use the term "technocrat" as a reference to economic experts who became members of the Mexican government beginning in the 1960s and who became especially prominent in the 1980s and 1990s.[6] Several top administrators and even presidents,

including Miguel de la Madrid (1982–1988) and Carlos Salinas de Gortari (1988–1994), trained in economics at Harvard and other prestigious US institutions. Political scientist Roderic Ai Camp called these late twentieth-century *técnicos* "Mexico's Mandarins."[7] Sociologist Sarah Babb referred to them as "new technocrats," economists who were often foreign-trained in "mainstream neoclassical economics [which] disposed them to look favorably on the dismantling of the developmentalist state."[8] In other words, many Latin Americanists associate "technocrats" with these neoliberal economists-turned-politicians.

This concept of "technocrat" evolved from broader visions. Pulling from Karl Marx, Max Weber, and German critical theorists, scholars in the 1960s, such as historian Theodore Roszak, painted technocrats in broad strokes as a (hyper)rationalist network of experts who had risen into the ranks of political power in countries around the world. This coincided with growing critiques of technological development in general. Intellectual Lewis Mumford had decades before lamented the machine-like regimentation of society and the dangers of blind production and consumerism. He amplified these fears in his publications from the 1950s to 1970s, casting aside much of his original optimism about technological possibilities, including about the people involved in developing and implementing them. He was joined in this anti-technocratic crusade by other influential scholars, including Herbert Marcuse, Jacques Ellul, and Roszak.[9] These authors and those influenced by them criticized technocrats as authoritarian, or at least a danger to democracy, because of the very claim made by many techno-bureaucrats that their work was scientific, in part universal, apolitical, and necessary. Some critics feared a complete technocratic takeover of human societies even if at the time it was a "tendency, and not a completely actualized phenomenon."[10] Roszak summed up this conception of technocracy well, defining it as

> that society in which those who govern justify themselves by appeal to technical experts who, in turn, justify themselves by appeal to scientific forms of knowledge. And beyond the authority of science, there is no appeal. Understood in these terms, as the mature product of technological progress and the scientific ethos, the technocracy easily eludes all traditional political categories. Indeed, it is characteristic of the technocracy to render itself invisible. . . . While daily political argument continues within and between the capitalist and collectivist societies of the world, the technocracy increases and consolidates its power in both as a transpolitical phenomenon following the dictates of industrial efficiency, rationality, and necessity.[11]

Roszak then went on to compare societies' technocratic acquiescence to baseball fans and umpires, where the fans are rooting for the teams while

the umpire is often the least visible person on the field. But ultimately it is the umpire who judges and enforces the rules of the game.

Other perspectives on technocracy that build on these intellectual predecessors come from more contemporary political theorists who discuss state power, legibility, democracy, and technocracy, such as James C. Scott, who criticizes "high-modernist ideology," which he sees as a strong "self-confidence about scientific and technical progress, the expansion of production, the growing satisfaction of human needs, the mastery of nature (including human nature), and, above all, the rational design of social order commensurate with the scientific understanding of natural laws."[12] He provides a critique of high-modernist thinking as hubristic, controlling, and oversimplified. Intending to make nature and society legible, planners (often engineers) have designed oversimplified environments that have commonly failed to understand the complexity of the natures and societies they attempt to control. In addition, these agents have too often failed to sufficiently consider and incorporate the knowledge of local peoples. None of *Technocratic Visions*' contributors use Scott's high-modernism terminology. Most of us complicate Scott's sometimes overly homogenous portrayal of the state and his tendency to paint engineers as uncritical implementors of state designs. His studies of the state, legibility, and power nonetheless remain valuable.

More recently, *The Technocratic Challenge to Democracy* (2020), edited by Eri Bertsou and Daniele Caramani, provides a more nuanced approach to technocracy and represents an evolving strain of thought about it among some political scientists and sociologists. In the introduction Caramani paints technocracy as a product of the intertwined but tense relationship between nationalism and industrialization. The former, he argues, leans ideologically democratic, egalitarian, and irrational; the latter tends toward hierarchy and rationalization. Caramani further argues that representative democracy has been an attempt to reconcile the two and that technocrats play important roles in these governments. At one extreme, representative democracies can tend toward the hyper-technocratic and elitist. At the other, they can lean toward the irrational and populist. Technocracy is on a continuum; it "takes various grades."[13] The most radically democratic governments still have some need for expertise and technocrats who are not always democratically selected. And even the most technocratic or otherwise authoritarian governments rely on "some form of popular mobilization and inclusion."[14]

The essays in *Technocratic Visions* reinforce this continuum approach, and they provide glimpses into how technocratic agents transitioned from a positivist, authoritarian dictatorship to the revolutionary and often populist-leaning governments. During this transition technocrats increased, not

decreased, in number and influence. Many technocratic engineers who participated in the Mexican Revolution did so believing that reliance on technological expertise would increase during the transition from a dictatorship to a representative democracy, not the other way around.[15] However, despite desires by some politicians, including technocrats, to create a representative democracy, Mexico's own attempts to reconcile revolutionary nationalism and industrialization ultimately resulted in the "soft authoritarianism" of the single-party state (1929–2000).

It was during the Second Industrial Revolution that technocrats first became prominent in Mexico. Sometimes their contributions were made behind the scene and not always democratically, but these experts were far from all-powerful.[16] And those technocrats who participated in the Mexican Revolution and the governments it spawned had to contend with the popular forces the revolution awoke. This volume explores the notion that technocrats have tended to be undemocratic, that they have viewed themselves as answerable to science and not political ideologies, local communities, or voters. It also examines the argument that technocrats and technological development have tended to reinforce inequalities instead of dissolving them, despite their rhetoric of technological fixes. The following chapters show that studying the lives of engineers in Mexico provides insights into the complicated but intertwined ways globalization, energy manipulation, revolution, and nation-state consolidation went hand in hand.[17]

PERIODIZATION AND HISTORICAL CONTEXT

The following chapters contribute to discussions about broad, global trends in professionalization and technological development, but they also demonstrate that studying experts and technologies in Mexico's specific context is useful.[18] Mexico's history—its institutions, its politicians, its diverse human and physical geography—were all important to engineers' and other technocrats' worldviews.

Situated between latitude 32° and 15° N, Mexico's environments vary significantly. Large stretches of arid desert exist across the north. There are high-altitude temperate zones in the center and tropical shrublands and jungles in the far south. The *tierra caliente*, or hot country, also includes tropical lowlands along the Gulf of Mexico, such as in Veracruz and Tabasco. Two mountain chains ride the Pacific and Atlantic coasts: the Sierra Madre Occidental and the Sierra Madre Oriental. Their offshoots squeeze the central plateaus. More mountains crisscross the southern tropical regions. Earthquakes occur frequently. Mexico has an abundance of mineral and biological resources, but there are few rivers navigable by large ships that transverse large cities. Historically, living standards, cultures, and connections between central Mexico and other peoples have varied significantly.

Pre-Spanish and colonial legacies influenced postindependence engineers and technocrats in important ways. When Spanish conquerors and their technical experts created Mexico City out of Tenochtitlán, they built heavily on the established network of communities connected by Aztec routes of trade, tribute, and governance.[19] However, pre-Spanish transportation was not constructed to consider transoceanic empires; overseas resource exportation; "old world" crops, animals, and manufactured goods; or an obsession with mining. Colonial engineers worked to map and obtain resources for the benefit of the Spanish empire and the colonial elite. With great difficulty and mixed success, experts and laborers built roads and port works to connect new settlements to agricultural areas, mining centers, and oceanic trade routes. Subsequent national-era engineers had to contend with this geography and these historical-cultural-environmental legacies as they strove to consolidate and strengthen Mexico as a sovereign nation-state.[20]

Mexico also has a long history of professional engineering that has influenced engineers' identities and work.[21] Colonial Mexico was the site of the first professional engineering school in the Americas. Carlos IV established the Real Seminario de Minas in Mexico City in 1792 to revitalize silver mining operations in Mexico. Earlier, Crown officials under Carlos III established the Academia de San Carlos in 1785. It was the first European-style fine arts academy in the Western Hemisphere. It also taught mechanical arts, including architecture. The majority of colonial students were criollo, that is, Europeans born in Mexico. Regularly denied top administrative positions in New Spain, some criollos sought careers as architects and engineers because they represented some of the most prestigious positions they could hold. Like their modern counterparts, these engineers often served as mediators. They regularly served elite interests but often took part in hashing out conflicts between Spanish officials, other criollos, and Indigenous, African, and *casta* communities.[22] As managers and mappers of Mexican people and resources, they also contributed to the establishment of a sense of early national identity by creating discussions about what resources were "Mexican."[23] Mining engineers, alongside a strong cadre of military engineers, were deeply intertwined with the imperial state, beginning a close association between engineers and the government. This tie continued with mining, civil, and military engineering well into the twentieth century. It still exists to some extent, though this relationship has changed significantly and has been challenged by neoliberal policies and the rise of technical schools, such as the Instituto Tecnológico y Estudios Superiors de Monterrey (1943), which have focused on training students to work in the private industrial sector for domestic and foreign corporations.[24]

Other historical realities that influenced Mexico's technical experts were Mexico's political elites' struggle to establish a stable state while fending off foreign invasions. Internal conflicts plagued Mexico's first decades following its independence in 1821. The secession of Texas in 1835 ignited a war between the secessionists and Mexico. Other states attempted secession as well, including the temporarily successful establishment of the Republic of Yucatán (1841–1847). The US annexation of Texas in December 1845 and disputes over Texas's boundaries led to the Mexican-American War (1846–1848) in which the US military invaded Mexico, occupied Mexico City, and took nearly half of Mexico's territory. Fourteen years after the conclusion of the war, France's Napoleon III ordered an invasion of Mexico. French forces eventually took Mexico City and established the Second Mexican Empire, which was ruled by Hapsburg duke Maximilian I (1864–1867). But Maximilian's government and military could never completely suppress the forces of Benito Juárez (1858–1872), who still claimed the mantle of Mexican sovereignty and waged war against Maximilian. Following the end of the US Civil War (1860–1865) and a decision by Napoleon III to remove most of his soldiers from Mexico, Juárez's forces prevailed, executing Maximilian I and more fully regaining control of the nation-state. The US military later invaded Mexico during the Mexican Revolution, temporarily occupying Veracruz (1914) and carrying out the Punitive Expedition into Chihuahua (1916).

These affronts on Mexican sovereignty fueled a strong sense of nationalism among many of the country's engineers who graduated in the late 1800s and early 1900s. At the same time they increasingly worked with engineers from the United States and other industrial nations. The governments of Juárez and especially Porfirio Díaz (1876–1880, 1884–1911) expanded engineering and technical education, creating national preparatory schools, new scholarships, and increased access for nonwhite and poorer students, even while entertaining new strains of racism. Educational leaders reorganized categories of engineering. They separated civil, mechanical, geographical, topographical, and mining engineering. Díaz and his close planners—many of whom were known as *científicos* because of their positivist prescriptions and claims to scientific expertise—realized that they needed more engineers and technicians to carry out the grand infrastructural goals and public works campaigns they believed essential to their motto "Order and Progress." Engineering students, especially civil engineers who sought to direct large public works projects, were infused with the idea that their work was a national duty, that it was necessary for the salvation and improvement of the country.[25]

One complicated challenge that students from the Escuela Nacional de Ingenieros (National School of Engineers) faced was that Mexico pos-

sessed immense cultural diversity and limited national infrastructure. Mexico was (and remains) home to hundreds of different Indigenous groups. Today this diversity is often celebrated, but for late nineteenth- and early twentieth-century national political leaders and civil engineers, it was often something to overcome. How could a mishmash of poorly connected, "uneducated" groups of people who spoke different languages protect Mexican sovereignty or build a strong domestic economy in the face of the United States? To defend that sovereignty, political leaders and engineers alike insisted that Mexico had to join the modern world and that its people needed to develop a stronger sense of common belonging, purpose, and exchange. That survival required new methods of repression and inclusion. It required fossil fuels. It required education, infrastructure, standardization, technical expertise, and engineering.[26]

But not everyone was on the same page. Many communities had mixed reactions to projects that challenged local lifeways and worldviews. Not all people within the confines of the political map of Mexico cared about being Mexican; their identities stood elsewhere. Some people had little desire to participate in capitalism or industrialization. Others in these same communities sought out advantages in the changing order.

To obtain greater control, political leaders worked to adapt practices used by Western imperial powers to unite and control their territories. These practices often required new energy sources, technologies, and technical expertise. Through using material infrastructure and public works to help consolidate control, Mexican leaders sought to display strength, a flavored conformity to modern norms, and to rule over their own sovereign nation, even while to many Indigenous groups Mexico was the imperial power. As for engineers, especially civil engineers, they commonly saw themselves as the people to unite, build, save, and "civilize" the nation.

Yet Díaz, late into his more than thirty years as president, often chose foreign experts for the most important projects, which disgruntled the youngest generation of Mexican engineers. This was in part due to a lingering bias that foreigners from the United States and parts of Europe were better and more practically trained than their Mexican counterparts. But it was not solely this rationale. Foreign firms also came with capital to offset government costs and brought new equipment. The heads of these firms often wanted the enterprises they invested in led by their own engineers. Many Mexican engineers nonetheless proved important to these projects: they knew the terrain. Some of them quickly obtained leadership roles. Others served as middle managers, working as go-betweens for top political leaders, business representatives, foreign engineers, and domestic technicians and laborers. During Díaz's final years in office, engineers increasingly gained high government positions and supervised significant

undertakings, including a massive potable water project in Mexico City carried out between 1908 and 1910. Many of the most prominent civil engineers to participate in the revolution had worked on Porfirian drainage and drinking water projects. Engineers also worked in the private sector on projects as diverse as wind pumps and electric piano players. Still, many young engineers had become frustrated at this use of foreign experts, limited state funding, and an aging generation of Porfirian politicos who restricted access to the high rungs of government bureaucracies. Students at the National School of Engineering created the Engineering Club in 1908. Its members focused on "national problems." They demanded further "Mexicanization" of the railroads, communications, and postal operations. Most of its members joined the opposition to Díaz in the 1910 election, and they subsequently sided against him during the revolution that followed.[27]

The revolutionary era (1910–1946) prompted new technical needs and calls for further Mexicanization, that is, a renewed emphasis on cultural unity, development carried out by Mexican laborers and experts, and increased Mexican control over industry and infrastructure.[28] And though many soldiers fought in the revolution for personal reasons, the return of lands, and to correct what they saw as previous wrongs, the leadership of the revolutionary faction that won prided itself on being harbingers of a more vibrant modernity. They also continued to rely on international exchanges in their attempts to implement changes. These trends were carried through the revolutionary governments of Venustiano Carranza (1917–1920), Álvaro Obregon (1920–1924), and those political leaders and aligned technocrats who subsequently built the single-party state that dominated Mexican national politics until 2000.

Mexico's proximity to and relationship with the United States also make it unique. The United States grew into a global power during this period, and it did so on lands it took from Mexico. US engineering programs grew dramatically, and US engineers spread their influence into Mexico and beyond.[29] Because of their connected history and geography, substantial changes in one place affected the other, and this became more pronounced as the United States became more powerful. US interests poured into mining, railroads, and the exportation of manufactured goods to Mexico. They greatly influenced, though did not determine, Díaz's rise to power and the subsequent Mexican Revolution. Today the countries are more entangled than ever, participating in a connected infrastructure and a multitude of international and bilateral agreements. Mexico was in 2021 the world's fifteenth largest economy and the United States' biggest trading partner. The long history and politics connected to the abutting and shared space of both countries have at times fueled defensive, nationalistic posturing and at other times intense mutual collaboration.[30]

While some aspects of Western standardization became increasingly common in Mexico by the mid-twentieth century—industrial components and production, scientific equipment, blue jeans and T-shirts—standardization was far from complete. And when engineers worked on projects based on foreign models and technologies, they had to contend with local peoples who resisted them or who wanted to influence the outcomes, which they often did. And even though most architects, engineers, and other professionals worked within international networks that promoted scientific and technical standardization, they had to adapt to Mexico's political and economic conditions, colonial legacies, geography, and cultural diversity. The resulting entanglement created its own distinctiveness in the resulting hybridity. Many state leaders, business owners, and designers embraced aesthetic and symbolic elements that reinforced perceptions of a Mexican uniqueness while simplifying Mexico's complexity—images that could then be projected globally to show Mexico as a sovereign nation that also exhibited a modern conformity to Western standards, systems, and tools.

The technological systems that Mexicans and foreigners in Mexico established during the Porfirian and revolutionary periods dramatically and unevenly altered Mexican communities in ways that are still prevalent. Technologies have a way of reinforcing the politics and power of their creators while also displaying the contestations over them. The technological systems that people developed in Mexico from the mid-nineteenth to the mid-twentieth centuries were created during a period of immense upheaval and change, both domestically and globally. For a variety of reasons, people established technological systems that were often impressive but rarely created in an all-inclusive or equitable fashion. They often came with unintended environmental, economic, and social consequences. Communities and individuals regularly had ideas other than those proposed about how these systems would be used.[31] Nonetheless, many of these systems became well established: roads, sewerage, port works, media, and telecommunications. Their presence has become normalized for many people even as access to them remains inequitable. Too rarely are they historically and critically examined.

If people desire to change these and other similar technological networks—and the social, political, and environmental issues built into them—it will be helpful to have a better understanding of why and how these systems were originally constructed, collaborated on, and fought over.

INTERSECTING HISTORIOGRAPHIES

The authors in this collection pull from a wide variety of primary and secondary sources. Of the latter you will see influences from Mexican public history. You will also find citations of empirical and theoretical works from

science and technology studies (STS) scholars, predominately from Mexico, the United States, and Europe. The contributors interact with a number of academic discussions about power dynamics, public space, technology and the environment, and how people determine technologies and how we are shaped by them in return.[32] Many of us engage with the literature on technocrats and technocracy. We also build on social, political, economic, and environmental histories of Mexico.

Mexican scholars have been creating histories about technology, engineers, and other experts in Mexico for some time; engineers have also been writing about and to themselves. Since the late 1800s engineers and architects participated in important journals, including the *Anales de la Asociación de Ingenieros y Arquitectos de México*, *El Minero Mexicano*, *El Arte y la Ciencia*, *Revista Mexicana de Ingeniería y Arquitectura*, and the *Memorias de la Sociedad Científica de Antonio Alzate*. These and several other periodicals were important channels of information exchange among Mexican engineers and architects. They remain important historical sources.

The history of science and technology as a field began in Mexico by the end of the 1960s with the founding of the journal *Anales de la Sociedad Mexicana de Historia de la Ciencia y de la Tecnología* in 1969. The discipline expanded further in the early 1980s, particularly following the establishment of the Sociedad Latinoamericana de Historia de las Ciencias y Tecnología in the city of Puebla in 1982. Juan José Saldaña and other contributors founded the journal *Quipu: Revista Latinoamericana de Historia de las Ciencias y la Tecnología*, which brought together scholars from across the Americas and beyond who sought to document, analyze, and historically contextualize the development of science and technology across Latin America.[33] This momentum drew on STS organizations established in the United States but also on Spanish historians who had begun to argue that the Spanish empire and its American colonies played a much larger and more dynamic role in the development of scientific thought in the sixteenth through eighteenth centuries than had been recognized.[34]

Many of *Quipu*'s first articles also focused on science in colonial Latin America, though the journal went on to publish on a myriad of topics spanning the precolonial to the twentieth-first century. In general, the more analytical articles in *Quipu* frame the history of science and technology within dependency and center–periphery/world systems theorizations while emphasizing unique accomplishments and adaptations in Latin America and the multidirectionality of scientific ideas and technological development in general. Most stridently, Saldaña, the organization, and the journal emphasized that any attempt to understand the networks of ideas and machines that make up the global system of science and technology is incomplete without including Latin America.[35]

Professionalization is a central part of the social and political history of technology and expertise, and a number of Mexican authors have focused on this topic.[36] The same year as the Puebla conference, Francisco Arce Gurza, Mílanda Bazant, Anne Staples, and Dorothy Tanek de Estrada published *Historia de las profesiones en México*, a foundational though largely descriptive book on the rise of academic, medical, and technical professions in Mexico.[37] Of particular importance to many of the contributors to our edited volume have been historical works on engineering.[38] Bazant, for example, published multiple works on the history of engineering education in Mexico. She provided some of the first accounts of engineering programs, especially from the late colonial period until the end of the Porfirian era. She argues that the Porfirian government and engineers made significant advancements in the quality and diversity of engineering programs. This expansion owed much to the increased social stability, foreign investment, and new material infrastructures of the era. In turn, the growth of engineering programs sparked further development. She additionally highlights the importance of foreign education to many of these engineers, who obtained study-abroad experiences as a part of their education, including at the École Centrale des Arts et Manufactures in Paris and at Harvard, Princeton, Columbia, and MIT in the United States.[39] Most recently Mexican historians have focused on the rise of Mexican civil engineering and its ties to architecture, something that some of the contributors to this volume build on.[40]

Historian Raúl Domínguez Martínez's *La ingeniería civil en México, 1900–1940: Análisis histórico de los factores de su desarrollo* (2013) is the most extensive history about Mexican civil engineering during the late Porfirian era and the revolution.[41] Domínguez contends that it's impossible to "clearly explain modern history in Mexico without attending to the history of infrastructure, and that this cannot be explained without reference to the evolution of civil engineering."[42] He emphasizes the important role of the state in the development of Mexico's civil engineering programs by arguing that political leaders saw the discipline as a practical science that was tied to very real needs. While Domínguez states that Mexico faced multifaceted problems bound within historical dependencies on foreign powers, geographic and cultural diversity, class divisions, and a lack of capital accumulation, he ultimately praises Mexican civil engineering as the scientific discipline that did more than any other to counter these deficiencies. All of the authors in *Technocratic Visions* agree with Bazant and Domínguez Martínez that the advancement of engineering in Mexico led to important material and societal changes, but we differ (among ourselves and with other publications) about the ultimate benefits and costs of those shifts.

Mexican social histories on health, public works, and infrastructure have also been particularly influential. A good example is Priscilla Connol-

ly's *El contratista de Don Porfirio: Obras públicas, deuda y desarrollo desigual* (1997), which contextualized Mexican histories of development and economics during the Porfirian era within a broader discussion of adaptions between the Mexican state, local labor traditions, and contracting firms.[43] As the title of her book states, and much like social histories of infrastructural technologies and Mexico since, it is also a work about unequal development. Most of Connolly's book focuses on the massive Mexico City drainage project and Veracruz port improvements that occurred during the first years of the twentieth century, both contracted to British financier Sir Weetman Pearson (titled Lord Cowdray after 1910). Similarly, a number of other works published in Mexico that have highlighted the relationship between private-state partnerships and the social processes and consequences of development in Mexico have focused on water networks and use, an important facet of Mexican life.[44]

Organized STS studies began in the United States shortly before they did in Mexico. Foreshadowed by prominent intellectuals of the early twentieth century such as Theodore Veblen and Mumford, STS studies commenced with the founding of the Society for the History of Technology (SHOT).[45] The origins of the organization started with the Humanistic-Social Research Project (1953–1955), a Carnegie Corporation of New York–funded undertaking by the American Society of Engineering Education. Spearheaded by historian Melvin Kranzberg, the networks that built on the Humanistic-Social Research Project evolved by 1958 into SHOT, which began publishing the journal *Technology & Culture* the following year.[46]

Historians of Mexico who write about technology have increasingly incorporated the works of STS scholars. There has been a clear influence from sociologists and philosophers who study the social construction of technologies, such as Wiebe E. Bijker and Thomas P. Hughes, and from Bruno Latour and his proponents who take the somewhat oppositional approach of tracing how associations among people, technology, and their environments more broadly construct society.[47] Although the chapters in this volume are rarely in direct conversation with Latour's Action-Network-Theory (ANT), they tend to reinforce his approach by providing empirical studies that explore the construction of society through the lens of engineers and other technical experts who mediated new technologies, national and international political forces, and local concerns.

Recent generations of STS scholars writing about Latin America have done much to bring Latin America into broader STS discussions. Edin Medina "uses the history of science and technology as a way to understand processes of political change."[48] She is best known for her book on the intersection of Chilean cybernetics, technological development, the global exchange of ideas, and the socialist aspirations of Chile's ill-fated president

Salvador Allende—*Cybernetic Revolutionaries: Technology and Politics in Allende's Chile* (2011). *Beyond Imported Magic: Essays on Science, Technology and Society in Latin America* (2014), a collection of essays she contributed to and coedited, reinforces the importance of Latin America in the development, adaptation, and multidirectionality of scientific and technological tools and networks. María M. Portuondo has authored books on Spanish and colonial Latin American science, especially during the sixteenth century. STS scholar Juan C. Lucerna's work on Mexican engineers and their identities is most directly linked to the studies in this volume. Contributors problematize but often reinforce the arguments he makes in "*De Criollos a Mexicanos*: Engineers' Identity and the Construction of Mexico" about the rising nationalism among engineers and the strong connection between engineers and the state from the late colonial period until the mid-twentieth century.[49] Yet, much more work still needs to be done on Mexican engineers who worked predominately in the private sector.

Most US historians currently writing about the history of technology in Mexico were trained in "traditional" history programs.[50] Their publications have largely been political, economic, environmental, labor, or cultural narratives that have placed individuals and communities at the forefront. They have introduced and contributed important discussions about identity, gender, inequality, authoritarianism, and democracy, among other topics, and provide strong historical contextualization and empirical archival evidence that is sometimes found wanting in philosophical and sociological studies.[51] These histories have nonetheless shown perspectives and arguments that reinforce STS social constructionist, co-constructivist, or ANT theorizations.[52]

The writings of economic historians, whose important works long dominated conversations about technological development in Mexico and Latin America, also highlight inequalities but focus more on international commodity chains or the ability of Latin American regions or nation-states to integrate successfully, or not, into the global capitalist market. Whereas many cultural histories of technology have focused on social agency and local or regional histories, many economic works have examined Latin American export economies, Import Substitution Industrialization (ISI), technology transfer, and the integration of transportation networks within global systems. Over the past couple of decades, economic historians have eschewed dependency theory, but the theme of dependence is still fairly common.[53] In these histories, colonialist legacies, personalist politics, weak education systems, capitalist development, a lack of nation-state-market integration, and insufficient specialists have limited the ability of Mexican and other Latin American governments and industrialists to fully integrate technological tools and networks originally developed by foreign special-

ists. Historical and geographic circumstances, deep institutionalized social inequities, and often political shortcomings have made it difficult for people in Latin American countries to mesh and benefit from the global capitalist system, despite significant natural resources in the region.[54]

CHAPTER OVERVIEWS

The chapters in this collection discuss a variety of experts and technologies, yet they also overlap significantly in their chronology and themes. Roughly half of the essays focus on the Porfirian era and the others examine the revolutionary and postrevolutionary eras, though there was significant continuity between the periods in matters of technology and expertise.

The first two chapters focus on architecture and the rise of civil engineering before and during the Porfirian period. In addition to examining specific people and projects, both chapters spend considerable time discussing the education system that trained these men and the construction materials they used. Marcela Saldaña Solis's "Poetry in Stone and Iron: Architect Emilio Dondé Preciat and the Construction of Modern Mexico City" looks at Mexico City's architecture during the late nineteenth century and the first years of the twentieth century through the lens of architect Emilio Dondé. Dondé straddled the shift of certain educational programs from architecture to civil engineering. His life and work show the contestations and conciliations among global, local, and national forces. In "Revelations from Rediscovered Artifacts of the National School of Engineers' Construction Materials Collection," Lucero Morelos Rodríguez and Francisco Omar Escamilla González use the recent rediscovery of portions of this collection to show how these construction materials correlated with the rise of Mexican civil engineering. They demonstrate how Porfirian officials and experts placed a growing emphasis on obtaining and standardizing materials, though the results were far from complete.

The authors in chapters three and four recognize some of the major accomplishments of engineers and other experts during the Porfirian era, but they are more critical of the consequences that major projects had on the lifeways and health of affected communities, especially those who were not members of the small-but-growing urban middle class and the elite. In "Engineering the Porfirian Landscape: Technology and Social Change in the Basin of Mexico, 1890–1911," James Garza focuses on the engineering and technical elements of the Gran Canal del Desagüe—a massive drainage project—and the voices of communities around Lake Texcoco that were affected by the undertaking. The project created substantial economic, ecological, and cultural changes for people in the region, provoking a number of petitions and complaints based on long-standing traditions but also from a desire to be better incorporated into economic markets and

modernization, something members of these communities felt the canal had sometimes hampered instead of improved. Rocio Gomez's "The Preoccupation with Safety: Mining Engineers, Education, and Practice in Modern Mexico" examines how mining engineers became increasingly tasked with limiting occupational accidents. She focuses mostly on the northern state of Zacatecas, arguing that safety was often illusory because too many engineers lacked the hands-on mining experience and local knowledge necessary to truly protect miners.

Chapters 5 through 9 emphasize the decades during and after the Mexican Revolution. Juan José Saldaña's "Revolutionary Technoscience: Science, Industry, Education, and the Mexican State, 1910–1946" is a broad overview of the evolution and intersection of science, industry, education, and the Mexican state during the revolutionary and postrevolutionary periods. He argues that the Constitutionalists and their successors focused even more than the Porfirian government on practical education and the use of technology and technological exports to develop Mexico's resources and to solidify the new revolutionary nation-state. For Saldaña the Mexican Revolution resulted in a genuine revolution in science and technocracy as much as, if not more than, a revolution in democracy and social justice.

Chapters 6 through 8 provide more specific studies about technology and engineers in US-Mexican relations and Mexican nation-state construction. My chapter, "Technocratic Diplomacy: Constitutionalist Engineers as Diplomats to the United States," focuses on how the Constitutionalist revolutionary faction led by Venustiano Carranza used technocratic diplomats, often engineers, to gain US support and a diplomatic edge during the Mexican Revolution. The chapter highlights the transnational character of professional and technocratic discourse.

Jayson Porter's and Pete Soland's essays focus on transportation technologies: roads and airplanes, respectively. In "Punitive Engineering and Military Modernization: Reform, Revolution, and Reconstruction in Mexico and the United States, 1916–1924," Porter tracks how the interactions of the US and Mexican militaries during the Punitive Expedition and revolution spurred national state-building projects in their respective countries. Mexican communities sometimes protested these infrastructural developments; yet at other times they collaborated, attempting to influence military, business, and government planners. Porter argues that the US military took lessons from its road-building and mechanization efforts during their Mexican expedition to the Western Front in Europe during World War I, showing that certain "Atlantic Crossings" originated in Mexico.[55]

Soland's "Flying Machines as a Measure of Mexico: National Reconstruction, the Cultural Revolution, and the Maturation of Mexico's National Aviation Program, 1921–1945" is a study of how revolutionary

government leaders imbued aviation technologies and policies with sociocultural symbolism that furthered their political goals for nation-state unification. These aspirations coincided with a drive to project an image of nationalistic modernity built on cultural inclusion by giving Indigenous names to aircraft. But underlying these names remained a modern Western developmentalist agenda that often cast aside many of the people whom the revolution was supposed to serve.

This volume concludes with Matthew Vitz's "A Social History of Urban Expertise: Between Techno-bureaucratic Rule and the Right to the City in Twentieth-Century Mexico." Exploring Mexico City's built environment from the Porfirian era until the 1985 earthquake, the piece contributes a fitting and powerful examination of how technical experts, bureaucrats, urban middle-class residents, and the city's poor disputed and collaborated on the development of their surroundings. Vitz shows that the consistent demands and influence of Mexico City residents challenge the notion that development lay strictly in technocratic hands. He argues that treating expertise as crucial to livable cities but also problematic for democratic participation provides clues to the possibilities and limitations behind constructing more accountable, equal, and sustainable cities.

Together, these essays exemplify many of the complexities, contradictions, and contestations involved in the creation of modern Mexico. The chapters also show that external and internal political and economic pressures to rationalize people and goods increased substantially from the mid-nineteenth to the mid-twentieth centuries. Many Mexican technocrats argued that a more unified Mexico and interconnected world would bring about more security and material wealth and, in turn, a happier and more prosperous people. Mexico, like much of the world, has become a wealthier place. Its engineers and architects have produced amazing works of structural art, have become leaders in geotechnics, and have expanded infrastructures that allow more people access to goods and services. But it is clear that development in Mexico has been hugely inequitable, and that rationalization as a whole has also worked as a form of control, a sort of repression that has limited as much as expanded individual and communal worldviews and possibilities. Material structures have played a large role in this change. Where we move, what we watch and listen to, how we work, and how we identify have been shaped dramatically by the options and limitations of the technological networks we live within. How and by whom these systems have been built are of paramount importance to understanding where we come from and where we are going. Building a more just and sustainable world requires rethinking these networks and engineering a fairer and more democratic process for future development.